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Dr. Robert Carovillano
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RE: Performance report on Grant NAGW-5152

Name and address of the grantee's institution: The Regents of the University of Colorado, Campus Box 19, Boulder, CO 80309-0019

Principal Investigator: Xinlin Li

For the period: 7/15/96 - 4/08/97

Title of Grant: "Analyzing the Loss, Energization, and Transport of Energetic Electrons in the Magnetosphere"

Significant results have been achieved under NASA SR&T funding NAGW-5152. By comparing data from WIND, SAMPEX, and the Los Alamos National Laboratory (LANL) sensors onboard geostationary satellites, we have shown that the solar wind is not an adequate source of radiation belt electrons through a process of radial transport which conserves at least the first adiabatic invariant. Thus, some other acceleration processes, such as wave-particle interactions resulting in the heating of part of the electron distribution, is required within or at the boundaries of the magnetosphere. This finding has answered a long-standing question: whether they are coming from outside or inside of the magnetosphere?

We have also investigated in detail the variation of the relativistic electrons in the magnetosphere during the 3-4 Nov. 1993 magnetic storm. We found that the loss of the inner part (L<4) of the outer zone electrons is partly due to the adiabatic effects associated with the decrease of Dst while the loss of most of the outer part, those electrons initially at L<4.0 are due to either precipitation into the atmosphere or drift to the Magnetopause because of the strong compression of the magnetosphere by the solar wind. The adiabatic effects associated with the increase in Dst definitely contribute to the recovery of the energetic electron flux. In addition for lower energies (<0.5 MeV) electrons, the recovery is also due to rapid radial diffusion driven by the strong magnetic activity during the recovery phase of the storm, during which enhanced injections of electrons with energies of tens of keV up to 300 keV are observed by the LANL sensors onboard geosynchronous orbits. Heating of electrons by waves or perhaps the above-mentioned recirculation press within the magnetosphere may contribute to the energization of the more energetic part (<1.0 MeV) of the outer zone electrons.

The following publications were partially supported by this grant:

Li, X., D. N. Baker, M. Temerin, D. Larson, R. P. Line, G. D. Reeves, M. D. Looper, S. G. Kanekal, and R. A. Mewaldt, Are energetic electrons in the solar wind the source of the outer radiation belt? Geophys. Res. Lett., in press, 1997

ABSTRACT: Using data from WIND, SAMPEX (Solar, Anomalous, and Magnetospheric Particle Explorer), and the Los Alamos National Laboratory (LANL) sensors onboard geostationary satellites, we investigate the correlation of energetic electrons in the 20-200 keV range in the solar wind and of high speed solar wind streams with relativistic electrons in the magnetosphere to determine whether energetic electrons in the solar wind are the source of the outer relativistic electron radiation belt. Though there is some correlation between energetic electron enhancements in the solar wind and enhancements in the outer radiation belt, the phase space density of 20-200 keV electrons in the solar wind is not adequate to supply the outer radiation belt electrons. Although lower energy electrons in the solar wind could be a seed population of the outer radiation belt, such lower energy electrons cannot achieve relativistic energies through the normal process of radial transport which conserves the first adiabatic invariant. Thus additional internal acceleration processes are required within the magnetosphere to produce the outer radiation belt. High speed solar wind streams are well correlated with increased magnetic activity and with increased fluxes in the outer radiation belt. The maximum correlation between the high speed streams and the radiation belt flux occurs with an increasing time delay for higher energies and lower L values. We conclude that acceleration processes within the magnetosphere which are well correlated with high speed solar wind streams are responsible for the outer radiation belt electrons.

Li, X., D. N. Baker, M. Temerin, T. E. Cayton, 0. D. Reeves, R. A. Christensen, J. B. Blake, M. D. Looper, R. Nakamura, and S. 0. Kanekal, Multi-Satellite Observations of the Outer Zone Electron Variation During the 3-4 November 1993 Magnetic Storm, J. Geophys. Res., in press, 1997.

ABSTRACT: The disappearance and reappearance of outer zone energetic electrons during the 3-4 Nov. 1993 magnetic storm is examined utilizing data from the Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX), the Global Positioning System (GPS) series, and the Los Alamos National Laboratory (LANL) sensors onboard geosynchronous satellites. The relativistic electron flux drops during the main phase of the magnetic storm in association with the large negative interplanetary Bz and rapid solar wind pressure increase late on 3 Nov. Outer zone electrons with E > MeV measured by SAMPEX disappear for over 12 hours at the beginning of 4 Nov. This represents a three order of magnitude decrease down to the cosmic ray background of the detector. GPS and LANL sensors show similar effects, confirming that the flux drop of the energetic electrons occurs near the magnetic equator and at all pitch angles. Enhanced electron precipitation was measured by SAMPEX at L>=3.5. The outer zone electron fluxes then recover and exceed pre-storm levels within one day of the storm onset and the inner boundary of the outer zone moves inward to smaller L (<3). These multiple-satellite measurements provide a data set which is examined in detail and used to determine the mechanisms contributing to the loss and recovery of the outer zone electron flux. The loss of the inner part of the outer zone electrons is partly due to the adiabatic effects associated with the decrease of Dst while the loss of most of the outer part (those electrons initially at L>=4.0) are due to either precipitation into the atmosphere or drift to the magnetopause because of the strong compression of the magnetosphere by the solar wind The recovery of the energetic electron flux is due to the adiabatic effects associated with the increase in Dst, and at lower energies (<0.5 MeV) due to rapid radial diffusion driven by the strong magnetic activity during the recovery phase of the storm. Heating of the electrons by waves may contribute to the energization of the more energetic part (>1.0 MeV) of the outer zone electrons.

The following presentation was partially supported by this grant.

Li, X., D. N. Baker, M. Ternerin, D. Larson, R. P. Lin, G. D. Reeves, J. B. Blake, M. Looper, S. Kanenkal, Effects of Solar Wind Conditions on the Relativistic Electrons in the Magnetosphere, Fall AGU, San Francisco, December, 1996.

This completes the performance report for NAGW-5152

Respectfully,

Xinlin Li
Principal Investigator

CC: Program Office (3)
Grant Officer, Mildred Garner, GSFC
NASA Scientific and Technology Information Facility (2)